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Electrical Conductivity of Sandstone and Granite During Fracture

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The existence of crustal conductivities higher than those of silicate rocks and minerals requires the addition of conductive phases such as carbon films, aqueous fluids, or silicate melts. Another requirement for enhanced conductivity is that these phases must form an interconnected network. Abrupt changes in electrical signals are sometimes observed prior to earthquakes and seismic events. The electrical signal prior to the 1989 Loma Prieta earthquake is a prime example. Various mechanisms and processes have been invoked to explain this phenomenon, but as yet it is unexplained. Carbon films are present in crustal rocks and are associated with disturbed zones in the KTB core, as well as along the surfaces of a fractured, 25-cm-long core recovered from ~7 km depth. We have measured the electrical conductivity of sandstone and granite at temperatures up to 530°C and pressures up to 150 MPa in an attempt to determine the effect of carbon films on rock conductivities and to investigate the catalytic deposition of carbon on new fracture surfaces as a possible mechanism of changing the electrical conductivity of rocks during fracture.

Experiments are performed in an internally heated gas pressure vessel with a load train that can produce strain rates between ~10^{-6} and 10^{-5}/sec. Different mixtures of gases are used as the pressure medium and the sample is unjacketed so as to be exposed to these gases. Thus far, CO/CO_2 mixtures (2 and 5% CO), argon, and air have been used as the pressure medium. During fracture, samples of Nugget sandstone, an Fe-bearing quartz sandstone, show an increase in conductance of up to 40%. Post-run analyses of fracture surfaces using x-ray photoelectron spectroscopy and time-of-flight SIMS indicate carbon films up to 4 angstroms thick on samples of Nugget sandstone run in CO/CO2 mixtures. The films are a mixture of carbon and hydrocarbons. Nugget sandstone samples run in argon have carbon present on fracture surfaces, but at approximately half the thickness found using CO/CO_2 mixtures. Samples of Westerly granite and St. Peter sandstone show no electrical conductance change on failure.

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